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(12) # EUROPEAN PATENT APPLICATION

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(71) Applicant:
Ein Hashofet Electrical Accessories
Kibbutz Ein Hashofet 19237 (IL)

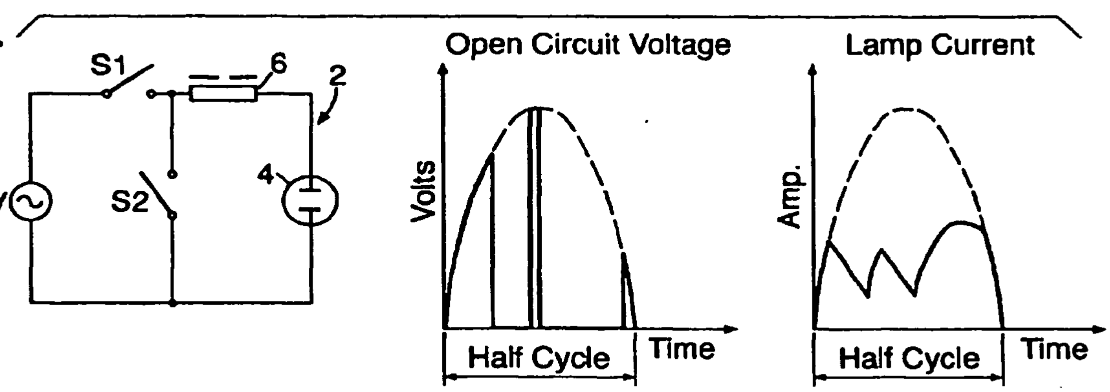
(72) Inventors:
- Erez, Eran
Ein Hashofet 19237 (IL)
- Fishbein, Omri
Ein Hashofet 19237 (IL)

(74) Representative:
Franks, Robert Benjamin
Franks & Co.,
352 Omega Court,
Cemetery Road
Sheffield S11 8FT (GB)

(54) **A dimmer and dimming lighting system**

(57) The invention provides a dimmable lighting system fed from a mains and connectable to at least one ballast and to at least one discharge lamp, the system including at least one switching component operable to connect the mains voltage to the lamp's circuit at certain periods of time and to provide a short circuit across the lamp's circuit between the periods of time, and a control circuit for sensing the mains voltage and selectively activating the switching component with reference to the mains voltage.

Fig.5.



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Description

Field of the Invention

[0001] The present invention relates to a dimmer and dimming lighting system that include discharge lamps and ballasts. In particular, the present invention is concerned with a dimmer and dimmable lighting systems consisting of magnetic ballasts and operated with low frequency mains voltage.

Background of the Invention

[0002] The current lighting technology utilizes dimmable systems as follows:

[0003] Dimming is performed by means of an additional ballast connected in series with the main ballast (Fig. 1). Thereby, the original open circuit voltage is maintained in any dimming state, while the lamp current is reduced but remains sinusoidal. The main disadvantage of this method is that an additional ballast must be added in series to each lamp in order to achieve dimming. Another disadvantage is that the reduced lamp current has a reduced slope near its zero crossing. Thereby, the re-ignition of the lamp at the beginning of each new half-current cycle becomes more difficult as the dimming becomes deeper.

[0004] Another method of dimming is performed by lowering the input voltage to the lighting system (Fig. 2). As compared to the above-described method, this method can be applied to a group of lamps using a single dimming device, but it has the disadvantage that the lower open circuit voltage in the dimming mode soon becomes insufficient for a new half cycle re-ignition. Hence, a dimming of only about 25% is possible with this method.

[0005] Still another method of dimming is performed by increasing the ballast current frequency (Fig. 3). This method has the disadvantage of increased ballast watt loss, with increased frequency and increased ballast noise, which, with magnetic ballasts, actually becomes intolerable.

[0006] A further method of dimming is performed by means of a phase-controlled electronic switch that disconnects the mains voltage during some parts of the voltage cycle (Fig. 4). The disadvantage of this method is the lamp current interruptions created by the switch. With deeper dimming, these interruptions become longer, which very soon makes new half-cycle re-ignition impossible unless the lamp cathodes are continuously heated by special means.

Summary of the Invention

[0007] It is therefore a broad object of the present invention to ameliorate the disadvantages of the prior art dimming systems and to provide a dimmer and a dimming system in which a deep dimming level is obtainable without lamp cathode heating.

[0008] In accordance with the present invention, there is thus provided a dimmable lighting system fed from a mains and connectable to at least one ballast and to at least one discharge lamp, said system comprising at least one switching component operable to connect the mains voltage to the lamp circuit at certain periods of time and to provide a short circuit across said lamp circuit between said periods of time, and a control circuit for sensing the mains voltage and selectively activating said switching component with reference to said mains voltage.

[0009] The invention further provides a dimmer for a dimmable lighting system fed from a mains and connectable to at least one ballast and to at least one discharge lamp, said dimmer comprising at least one switching component operable to connect the mains voltage to the lamp circuit at certain periods of time and to provide a short circuit across said lamp circuit between said periods of time, and a control circuit for sensing the mains voltage and selectively activating said switching component with reference to said mains voltage.

[0010] In general, the present invention combines the advantages of high open circuit voltage with the advantages of continuous lamp current having steep slope at zero crossing, together with the advantages of handling many lamps by means of a single switching component. More specifically, the advantages of high open circuit voltage constitute stable lamp operation and safe half-cycle re-ignition, while the advantages of continuous lamp current having steep slope at zero crossing induce even more stable operation and reduction of the required re-ignition voltages. The advantage of handling many lamps operated with magnetic ballasts by means of single switch is simplicity and low cost as well as the option to use the invention with existing lighting systems.

Brief Description of the Drawings

[0011] The invention will now be described in connection with certain preferred embodiments with reference to the following illustrative figures so that it may be more fully understood.

[0012] With specific reference now to the figures in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in prac-

tice.

[0013] In the drawings:

Figs. 1 to 4 are circuit diagrams and characteristic curves of prior art dimmers;
Fig. 5 is a circuit diagram and characteristic curves of a preferred embodiment of the present invention;
Fig. 6 is a block and circuit diagram of a dimming arrangement for a plurality of lamps utilizing the dimmer according to the present invention;
Fig. 7 is a block diagram of the dimming system according to the present invention;
Fig. 8 is a circuit diagram of an embodiment of a dimming system according to Fig. 7, and
Fig. 9 is a further embodiment of a dimming arrangement, and
Fig. 10 is a circuit diagram of an embodiment of the switch of Fig. 9.

Detailed Description of Preferred Embodiments

[0014] In contradistinction to the above-described prior art dimmers, in Fig. 5 there is illustrated a dimmer 2 powered from a mains and connectable across a discharge or fluorescent lamp 4. The dimmer consists of two switches S_1 and S_2, e.g., solid state switches, and a ballast 6. S_1 is connected between the mains and the lamp's circuit components 4 and 6; S_2 is connected in parallel to the lamp's circuit components 4 and 6. Switches S_1 and S_2 operate in such a manner that when S_1 is open, S_2 is closed, and *vice-versa*. Thus, the lamp's current continues to flow, due to energy stored in the magnetic ballast 6, as seen in the characteristic curves. The high open circuit voltage and steep lamp current at zero crossing facilitate deep dimming without special cathode heating.

[0015] The dimmer according to the present invention can be utilized as a central dimmer for a plurality of discharge lamps, as illustrated in Fig. 6. The central dimmer 2 is advantageously connected across the mains via a power factor correction capacitor 8. The discharge lamps 4, in this case, compact fluorescent lamps (CFL), are connected to the mains lines 10 via suitable *per se* known adaptors 12, each including a magnetic ballast (not shown), as opposed to the ballast 6 shown in Fig. 5, which constitutes a separate component.

[0016] The dimmer of the dimmable lighting system according to the present invention is illustrated in Figs. 7 and 8. Fig. 8 merely represents a preferred embodiment. The mains feeds a power supply 14, composed of two transformers T_2 and T_3, leading to two bridges D_1 and D_2 and, via capacitors C_3 and C_4, to the rest of the circuit for supplying the required low DC voltages to the dimmer. The mains also directly feeds a phase detector 16, an optional zero crossing detector and a switching component 18. The mains phase detector includes a transformer T_1 leading through resistors R_1-R_6 to comparators U1A and U1B and from there to a logic circuit 20, which governs the operation of the switching components 18 in accordance with the setting of the dimming control 22, optionally including a display. The logic circuit consists of two monostable units U3A and U3B and two capacitors C_1 and C_2 leading, via resistors R_9-R_{11}, to comparators U2A and U2B.

[0017] According to this embodiment, switching component 18 comprises comparators U4A and U5A, and transistors Q_1-Q_6, respectively leading to bridges D_3 and D_4. The logic circuit leads the switching component through two opto-couplers 24 and 26. The dimming control unit 22 is here embodied by the adjustable resistors R_7 and R_8.

[0018] Hence, as can be understood, the phase detector 16 monitors the mains and identifies its phase, e.g., zero crossings, and transfers this information to the logic circuit 20. Substantially upon the mains voltage crossing the zero line, the logic circuit activates the switching component, at least twice during each half-cycle of the mains voltage, for a duration of time preset by the dimming control, as illustrated in Fig. 5.

[0019] The switching component thus facilitates continuous lamp current at the dimming state while maintaining the original open circuit voltage and nearly the original current slope at zero crossing. This facilitates very effective dimming without special cathode heating, although cathode heating could just as well be applied.

[0020] Fig. 9 illustrates another embodiment of a dimmable lighting system according to the present invention, suitable for assuring efficient re-ignition of a discharge lamp. Seen is a discharge lamp 4, with an igniter 28 connected thereacross and a ballast 6 connected to a four-position switch 30. Contacts S_3 and S_6 lead via diodes 32, 34 to one line of the mains, while contact S_4 leads directly to the same line and contact S_5 leads directly to the other line of the mains. In addition, contacts S_3 and S_6 are respectively connected via capacitors 36, 38 to said other line of the mains. Thus, during the periods of time that switch 30 does not directly contact the mains, it contacts alternative voltage sources.

[0021] The operation of the dimmer is as follows: At each cycle of the mains, capacitors 36, 38 are charged to the main's peak voltage. At the termination of the positive half cycle of the mains voltage, the current in lamp 4 will rapidly decrease. In order to slow down the rate of decrease of the current, namely, to delay as far as possible its reaching zero, so as to increase the phase difference between the current and voltage with a view towards improving the lamp's re-ignition, the contact S_3 of switch 30 is closed for a short period or periods of time, thereby causing further current to flow through the lamp. The voltage on the capacitor 36 will decrease until the next positive cycle, in which it will recharge again through diode 32. The operation of the circuit during the negative half-cycle will be the same in conjunction with contact S_6 of switch 30 and capacitor

38. The application of the additional current to the lamp at the proper timing can be easily controlled on the basis of constant measurement of the zero crossing of the mains voltage waves, e.g., in synchronization with phase detector 16 (Figs. 7 and 8).

[0022] A solid-state-based embodiment of the four-position switch 30 of Fig. 9 is shown in Fig. 10. The switch includes four transistors Q_1 to Q_4 for driving current respectively through insulating transformers T_1, T_2, T_8 and T_9. Transistor Q_5 and diode D_6 constitute an OR gate for operating transistor Q_4, and capacitors C_1 and C_2 serve as filters. Diodes D_1 to D_4 facilitate flow of current after cut-off of current to the transformers T_1, T_2, T_8 and T_9. The latter provide operating voltages to the gates of transistors Q_{14} to Q_{19}, while transistors Q_6 to Q_9 serve as the non-conducting arrangement for transistors Q_{14} to Q_{19} by calibrating the gates thereof. Diodes D_5, D_{23}, D_{28} and D_{24} enable charging the gates of transistors Q_{14} to Q_{19}, and diodes D_{16}, D_{17}, D_{18}, D_{30}, D_{31}, D_{27} and D_{28} are used as OR gates for operating the non-conducting state of transistors Q_{14} to Q_{19}. Zener diodes D_{19}, D_{20}, D_{21} and D_{22} protect the gates of transistors Q_{14} to Q_{19} against high voltage, while resistors R_1 to R_4, R_{11}, R_{13}, R_{15} and R_{17} limit the current flow to these transistors. Resistors R_5, R_{10}, R_{12}, R_{14} and R_{16} are discharge passageways from the bases of the transistors Q_4, Q_6 to Q_9. Capacitors C_3, C_4 and C_6 retain the charge on the gates of transistors Q_{16} to Q_{19}.

[0023] The operation of the switch 30 is as follows: a voltage pulse applied to input "MAIN ON" activates transistor Q_3, causing current to flow through the primary of transformer T_8. The resulting voltage across points 3, 4 of the secondary coil of the transformer charges transistors Q_{14} and Q_{15} through diode D_{23}, rendering the transistors conductive. Simultaneously, the voltages built up across points 5,6; 7,8 and 9,10 of the secondary coils of transformer T_8 render transistors Q_6, Q_7 and Q_9 conductive, causing discharge of the gates of transistors Q_{18}, Q_{19}, Q_{16} and Q_{17}, respectively, thus preventing the flow of current therethrough. A similar operation takes place upon the appearance of a voltage pulse across inputs "BOOST+", "BOOST-" and "FREE WHEEL."

[0024] It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrated embodiments and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

Claims

1. A dimmable lighting system fed from a mains and connectable to at least one ballast and to at least one discharge lamp, said system comprising:

   at least one switching component operable to connect the mains voltage to the lamp's circuit at certain periods of time and to provide a short circuit across said lamp's circuit between said periods of time, and
   a control circuit for sensing the mains voltage and selectively activating said switching component with reference to said mains voltage.

2. The dimmable lighting system as claimed in claim 1, wherein said switching component consists of a changeover solid state switch.

3. The dimmable lighting system as claimed in claim 2, wherein said changeover solid state switch consists of a first on-off AC switch connected between said mains and said lamp circuit and a second on-off AC switch connected in parallel to said lamp circuit.

4. The dimmable lighting system as claimed in claim 1, wherein said ballast is a coil-core magnetic ballast.

5. The dimmable lighting system as claimed in claim 1, wherein said control circuit senses zero crossing of the mains voltage and changes the state of said switching component at least twice during each half cycle of said mains voltage.

6. The dimmable lighting system as claimed in claim 1, wherein said control circuit comprises means for adjusting the level of light intensity.

7. The dimmable lighting system as claimed in claim 1, wherein said control circuit comprises a sensor for identifying mains voltage zero crossing and for activating timing means for actuating said switching component at certain time intervals following the zero crossing.

8. A dimmer for a dimmable lighting system fed from a mains and connectable to at least one ballast and to at least one discharge lamp, said dimmer comprising:

   at least one switching component operable to connect the mains voltage to the lamp circuit at certain periods of time and to provide a short circuit across said lamp circuit between said periods of time, and
   a control circuit for sensing the mains voltage

and selectively activating said switching component with reference to said mains voltage.

9. The dimmable lighting system as claimed in claim 1, wherein, during periods of time that said switching component does not contact the mains, it contacts alternative voltage sources.

10. The dimmable lighting system as claimed in claim 9, wherein said alternative voltage sources are capacitors.

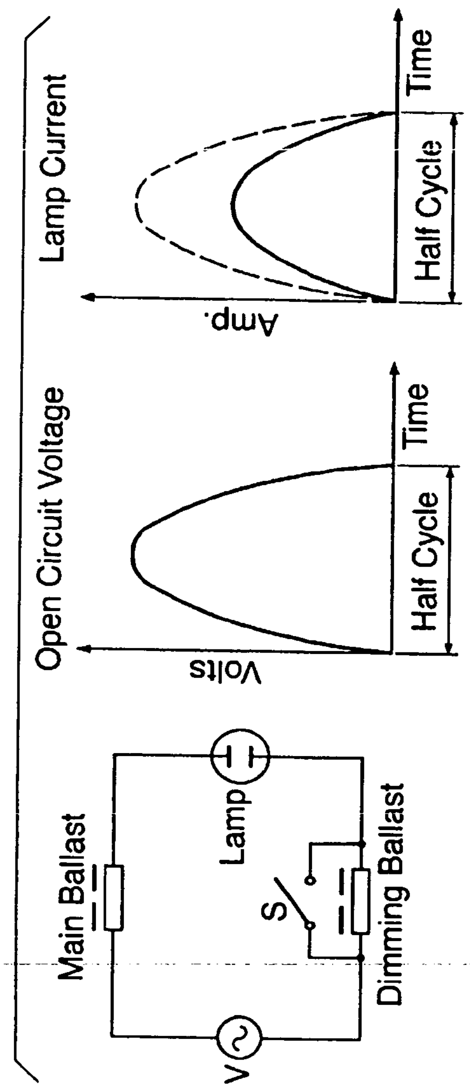


Fig.1. (Prior Art)

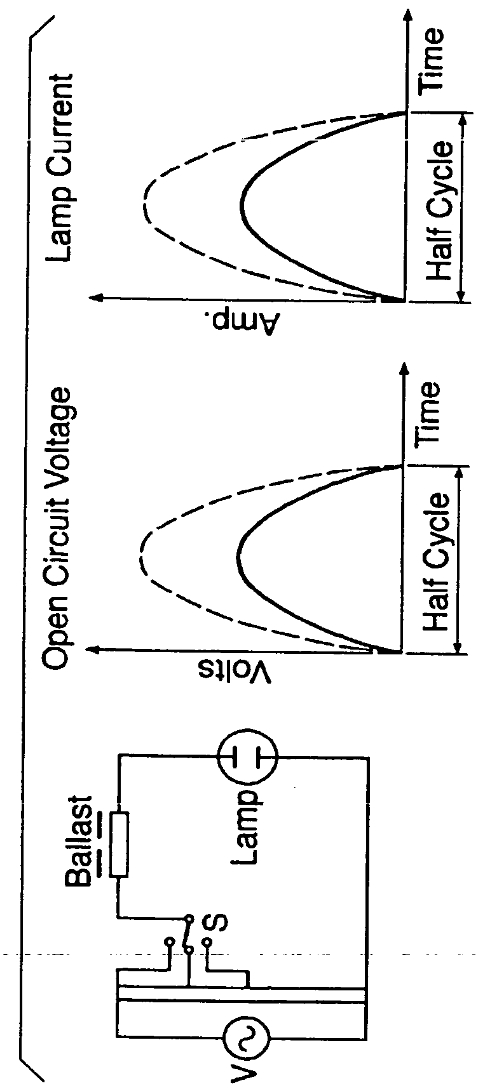


Fig.2. (Prior Art)

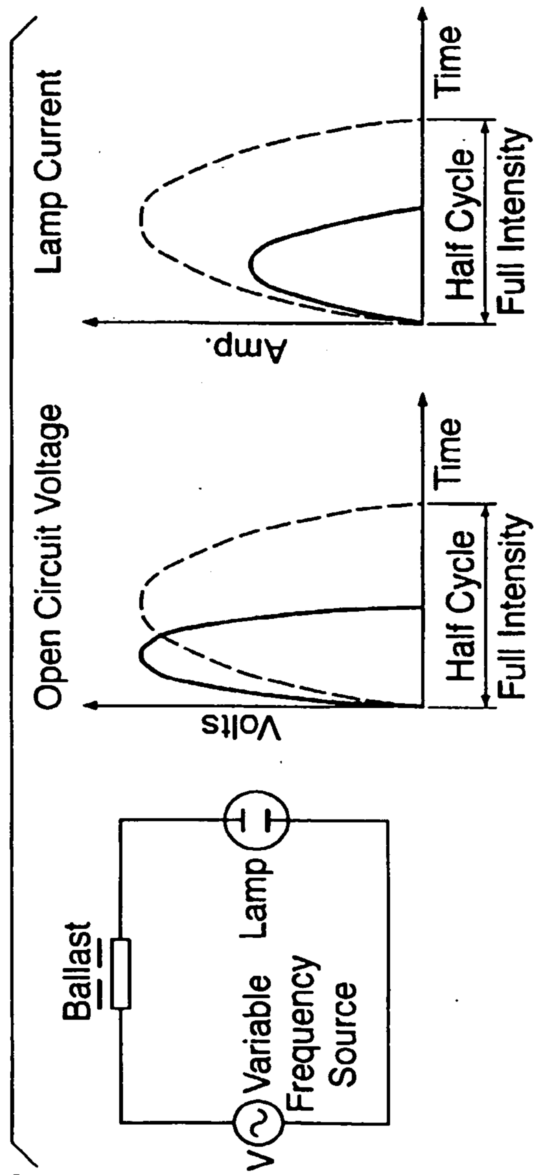


Fig.3. (Prior Art)

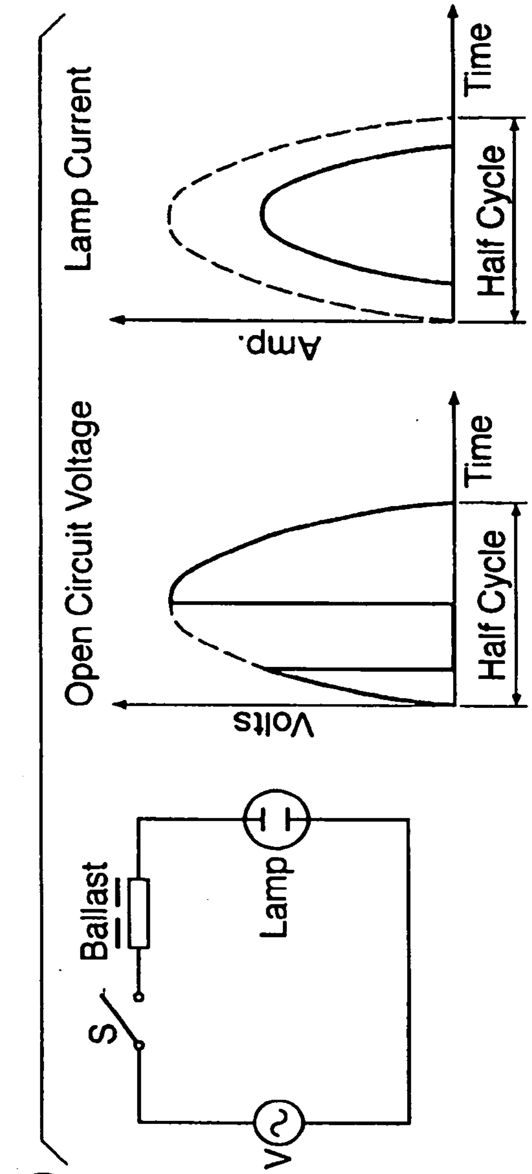
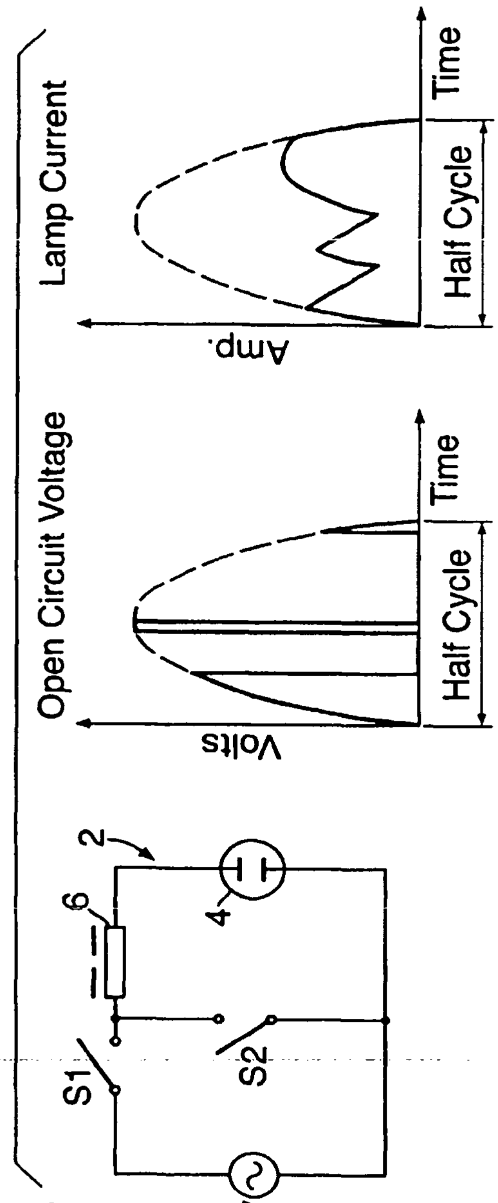
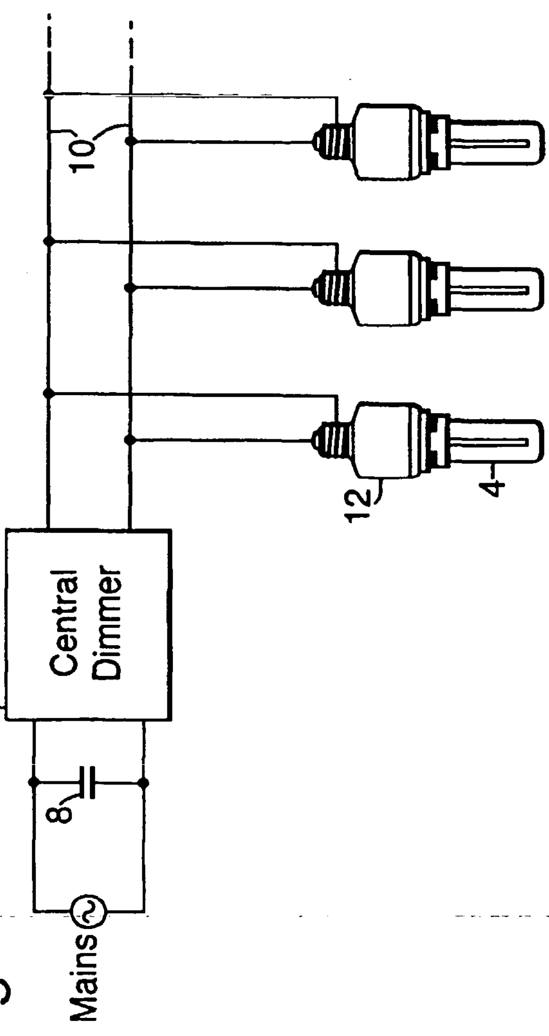


Fig.4. (Prior Art)



Open Circuit Voltage
Volts
Time
Half Cycle
Lamp Current
Amp.
Time
Half Cycle
S1
S2
V
2
4
6

Fig.5.



Mains
8
2
Central Dimmer
10
12
4

Fig.6.

Fig.7.

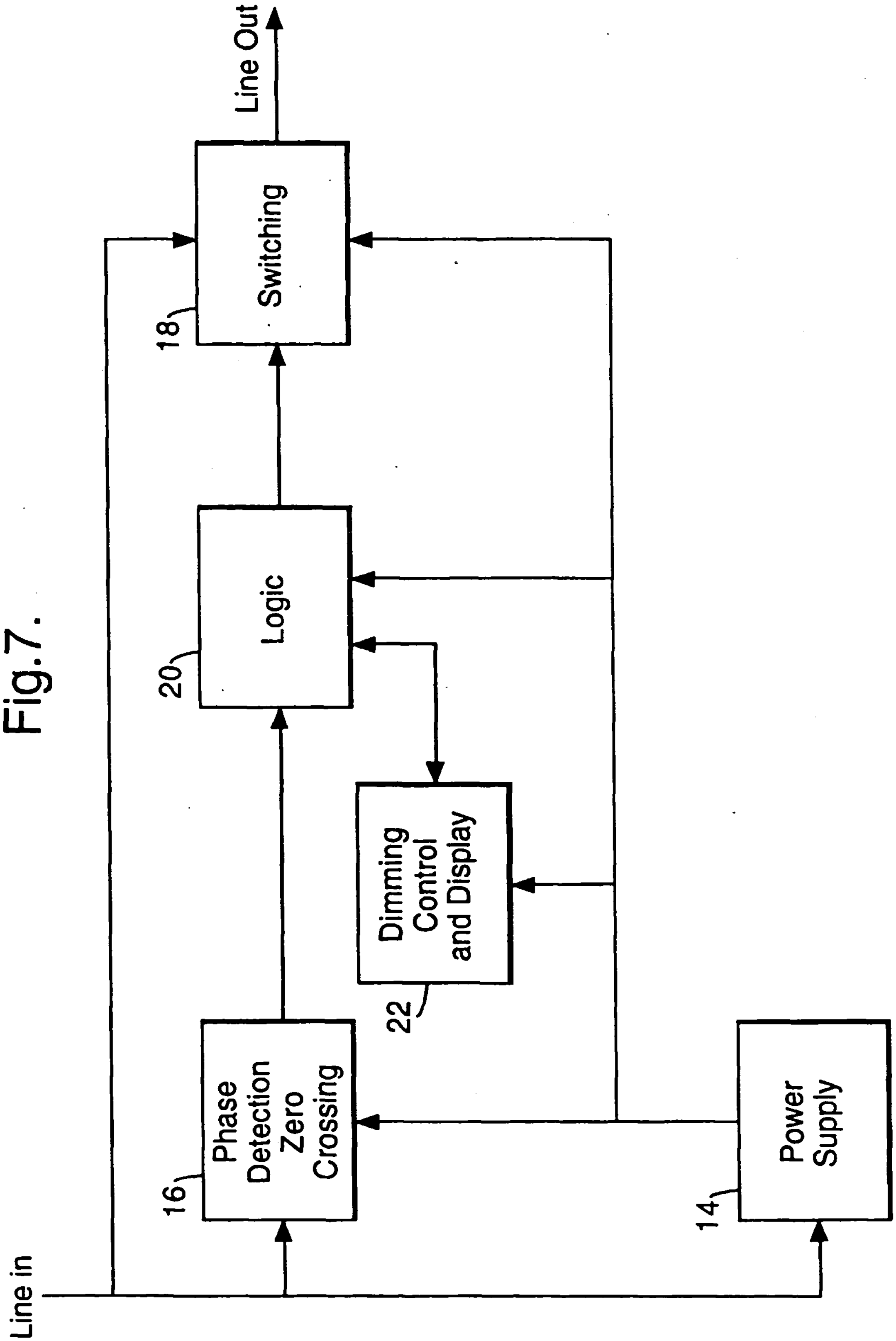
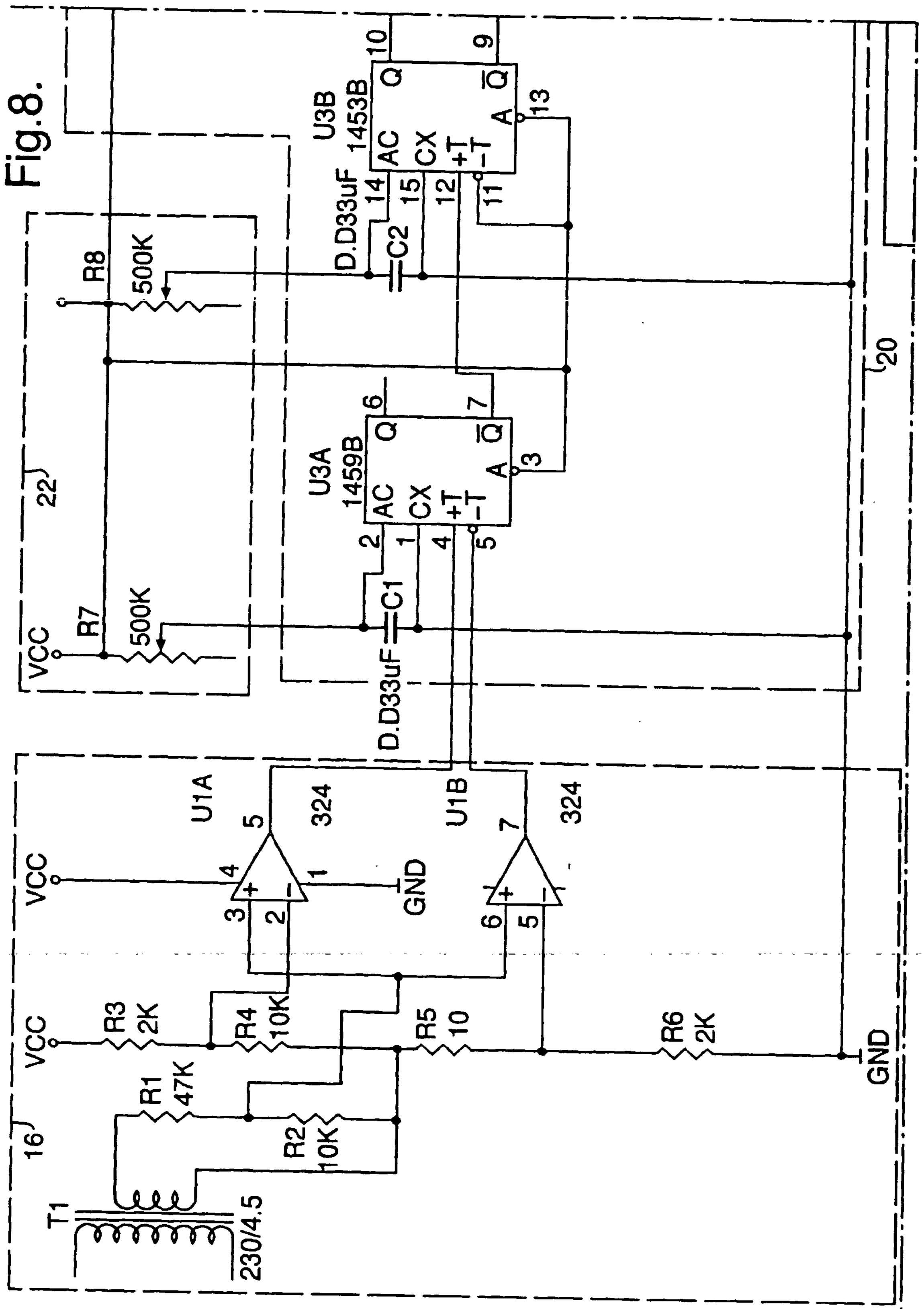

Line in
Line Out
Switching
18
Logic
20
Dimming Control and Display
22
Phase Detection Zero Crossing
16
Power Supply
14

Fig.8.


U3B
1453B
AC
Q
CX
+T
-T
A
Q̄
10
9
13
14
15
12
11
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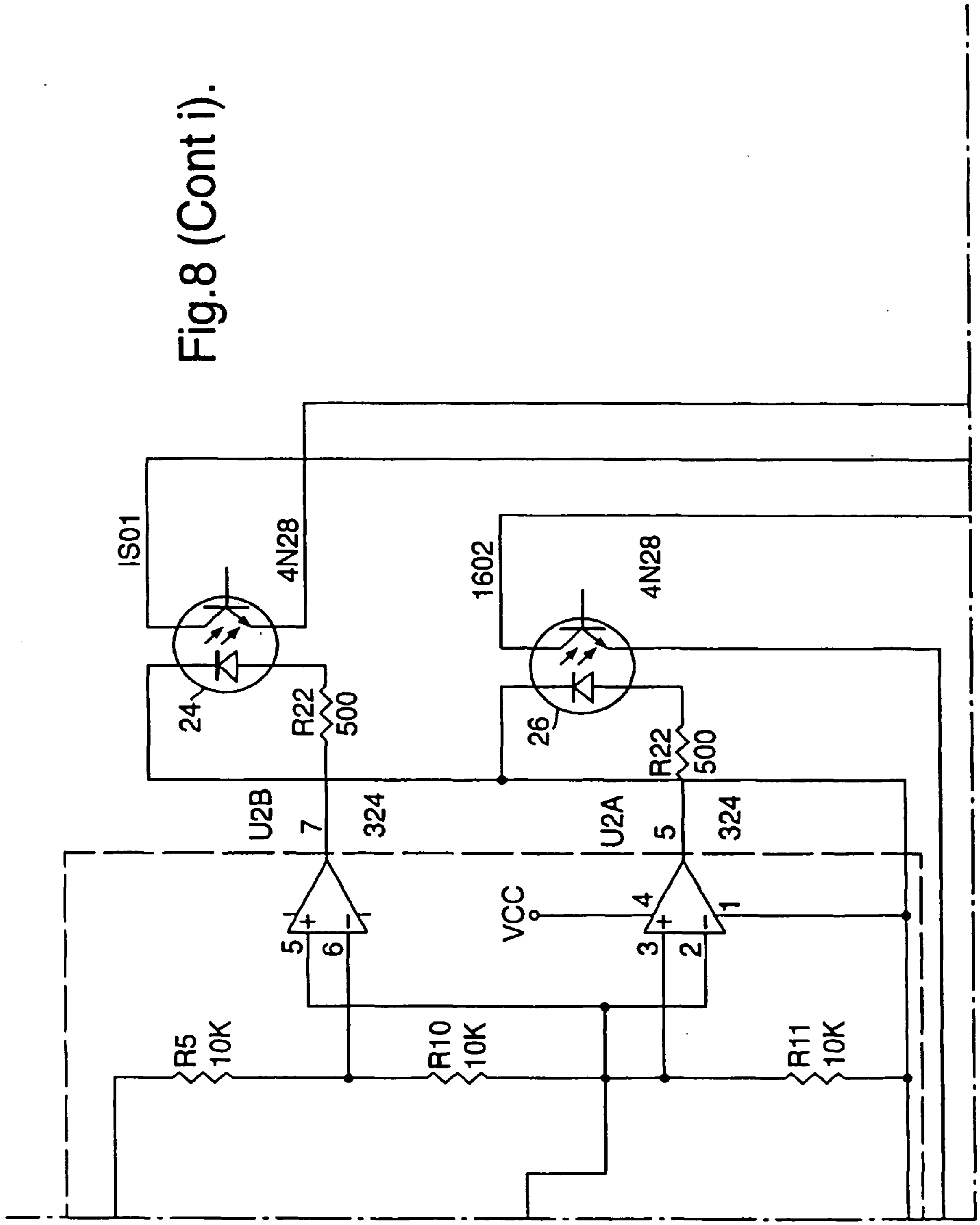
C2
R8
500K
22
VCC
R7
500K
U3A
1459B
6
7
3
2
1
4
5
C1
D.D33uF
20
U1A
324
U1B
324
VCC
GND
R3
2K
R4
10K
R5
10
R6
2K
R1
47K
R2
10K
16
T1
230/4.5


IS01
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24
R22
500
1602
4N28
26
R22
500
U2B
7
324
U2A
5
324
VCC
4
5
6
3
2
1
R5
10K
R10
10K
R11
10K

Fig.8 (Cont i).

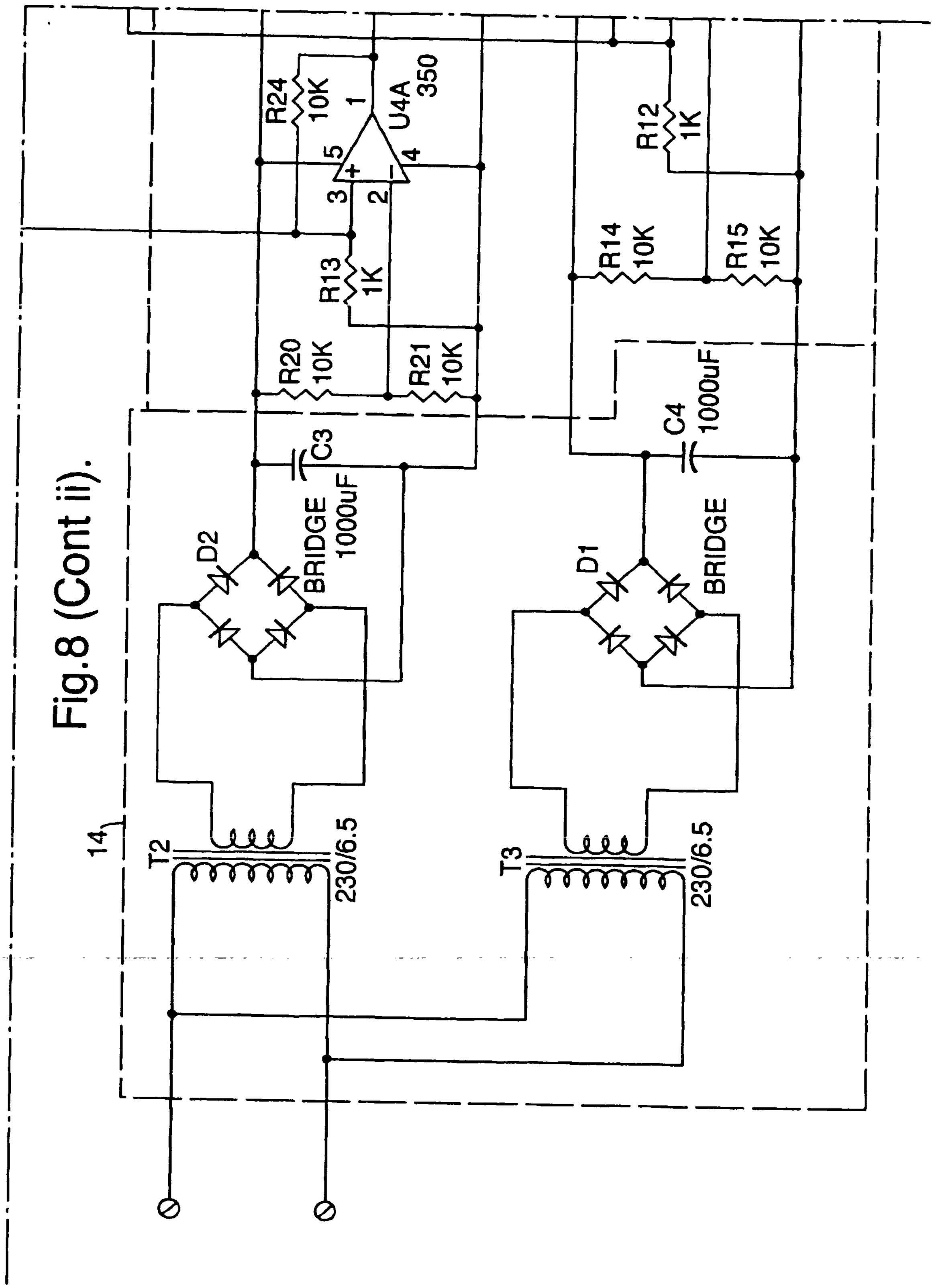

R24
10K
1
U4A
350
5
4
3
2
R12
1K
R14
10K
R15
10K
R13
1K
R20
10K
R21
10K
1000uF
C4
1000uF
C3
BRIDGE
1000uF
D2
D1
BRIDGE
14
T2
230/6.5
T3
230/6.5

Fig.8 (Cont ii).

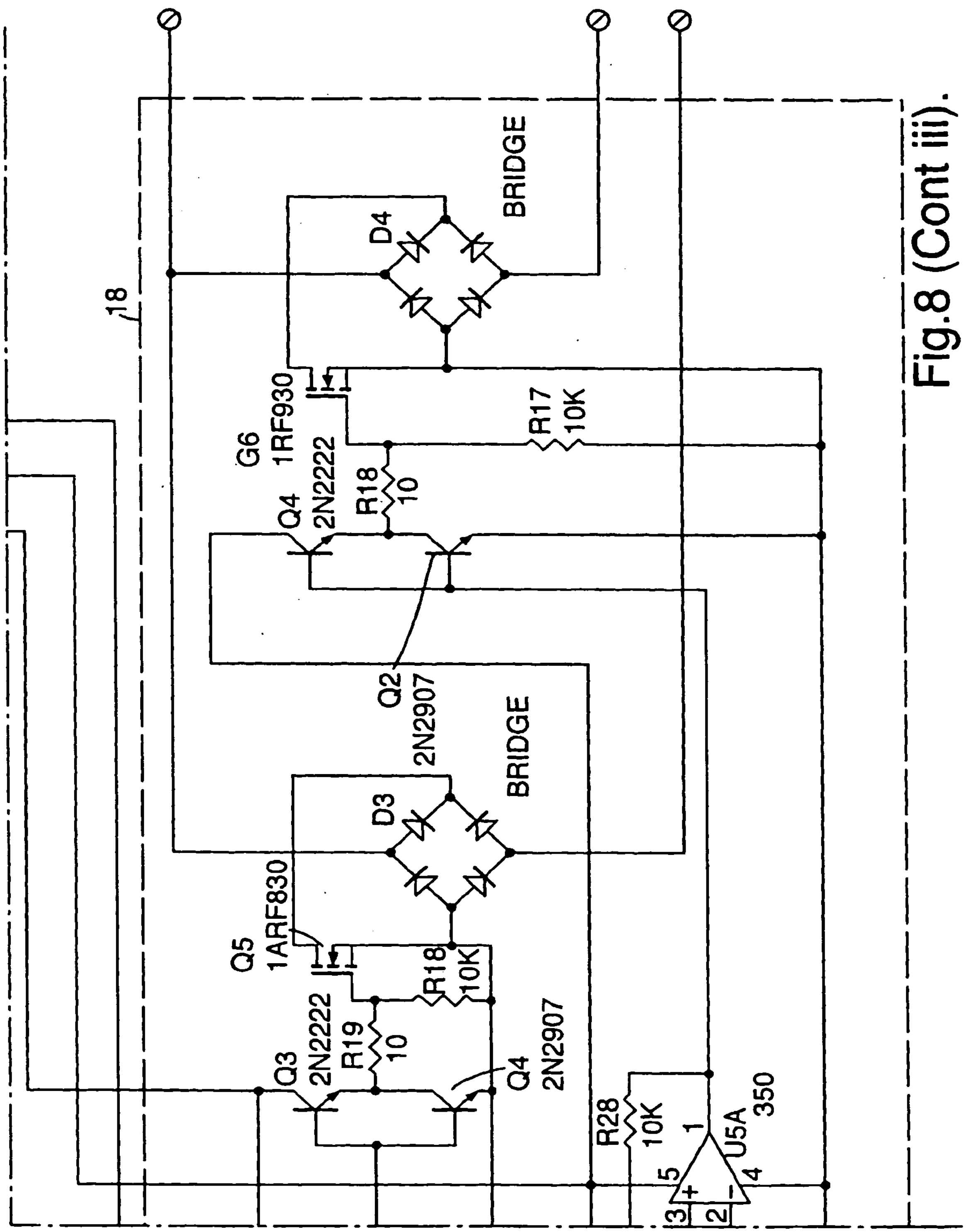


Fig.8 (Cont iii).

Fig.9.

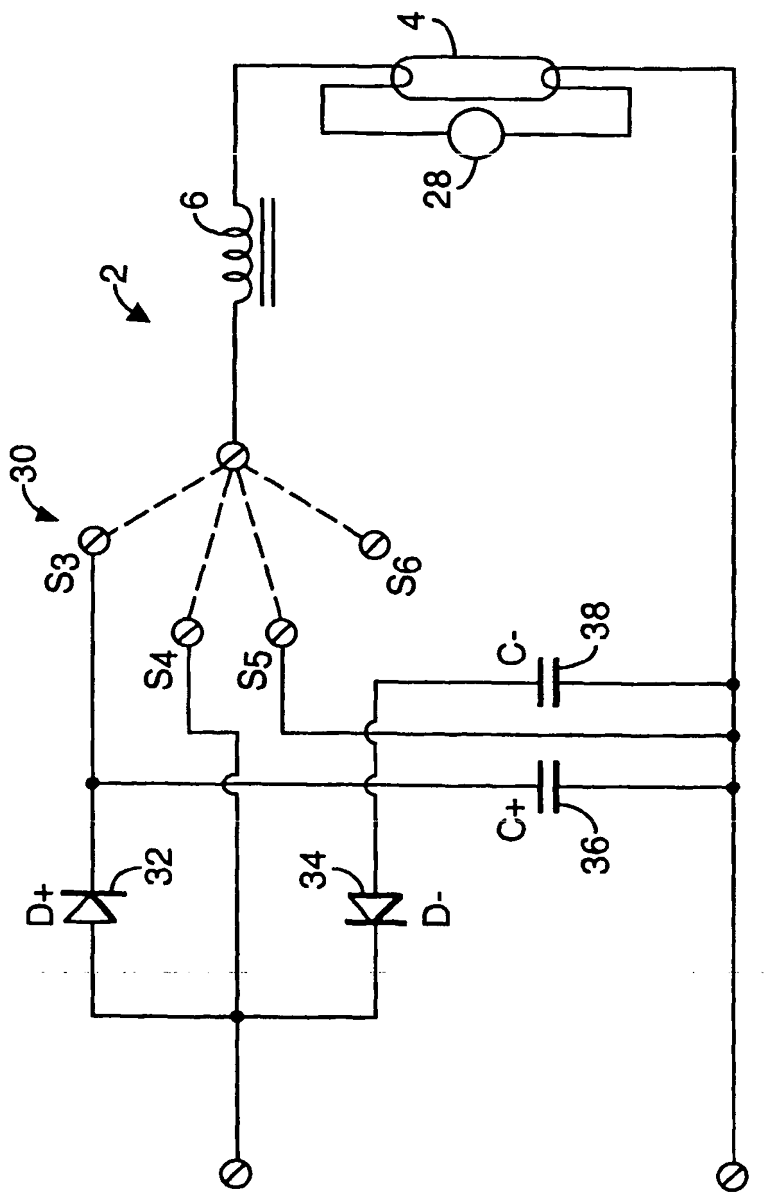
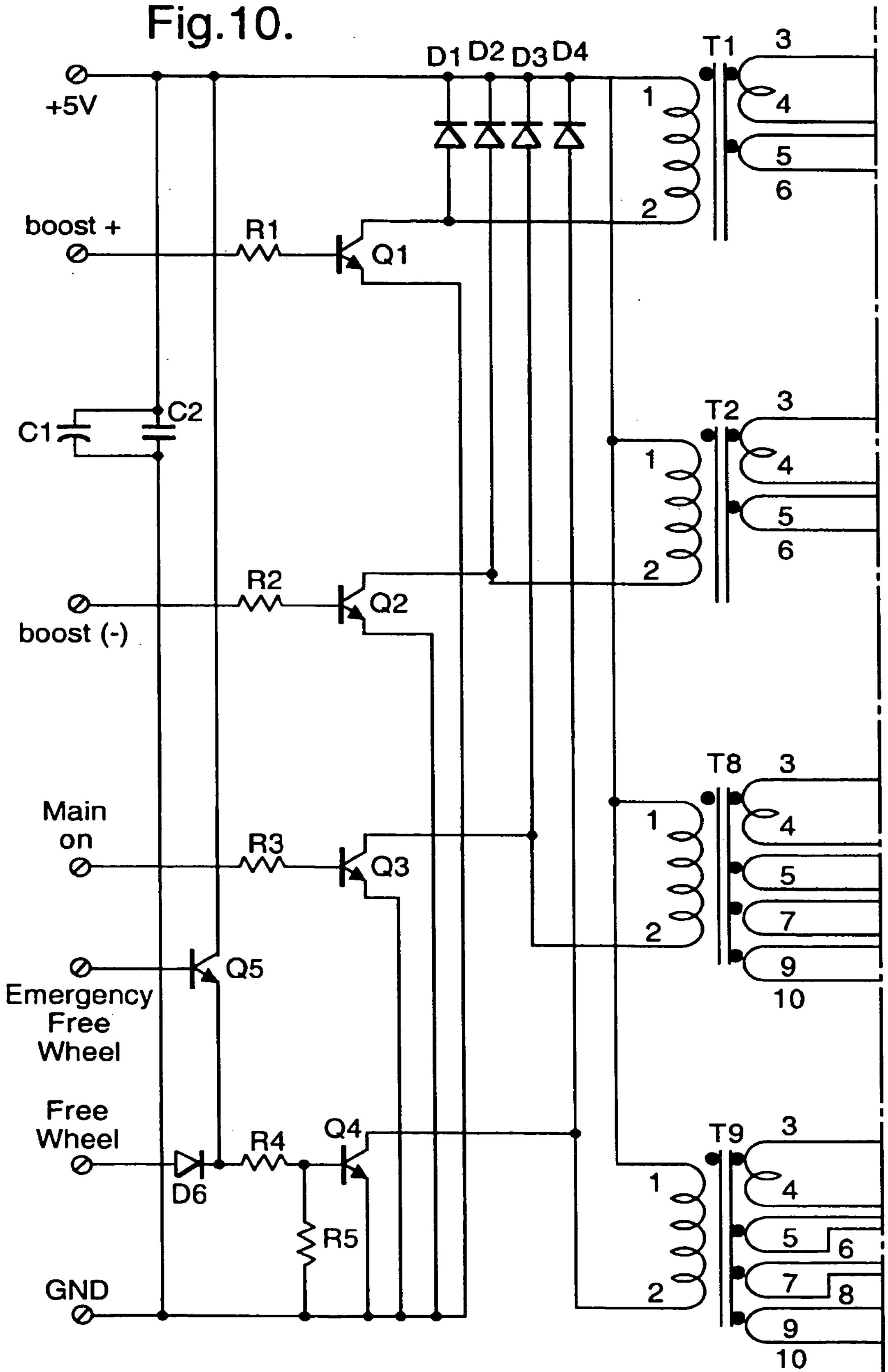


Fig.10.



+5V
boost +
boost (-)
Main on
Emergency Free Wheel
Free Wheel
GND
C1
C2
R1
R2
R3
R4
R5
Q1
Q2
Q3
Q4
Q5
D1
D2
D3
D4
D6
T1
T2
T8
T9
1
2
3
4
5
6
7
8
9
10

Fig.10 (Cont i).

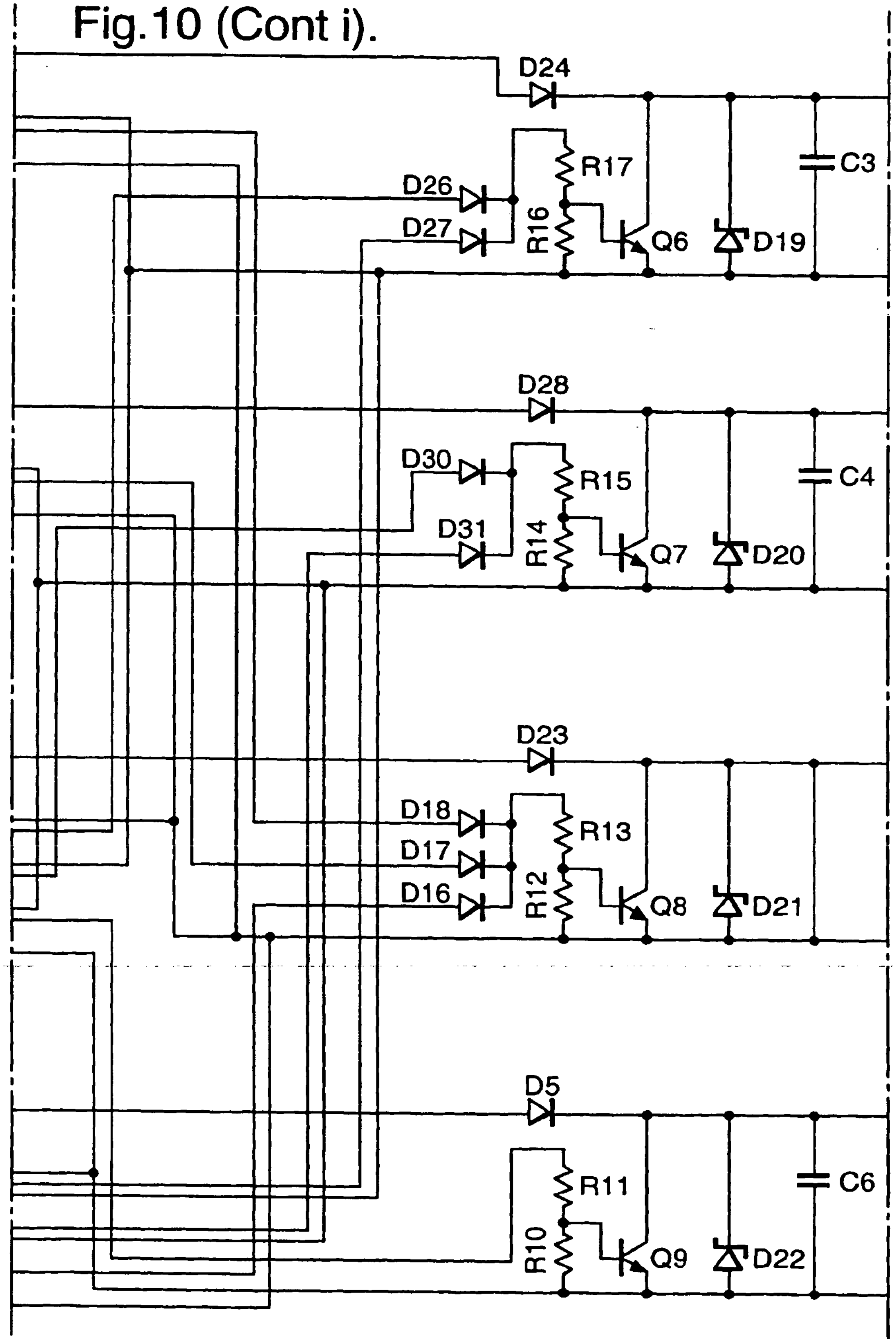
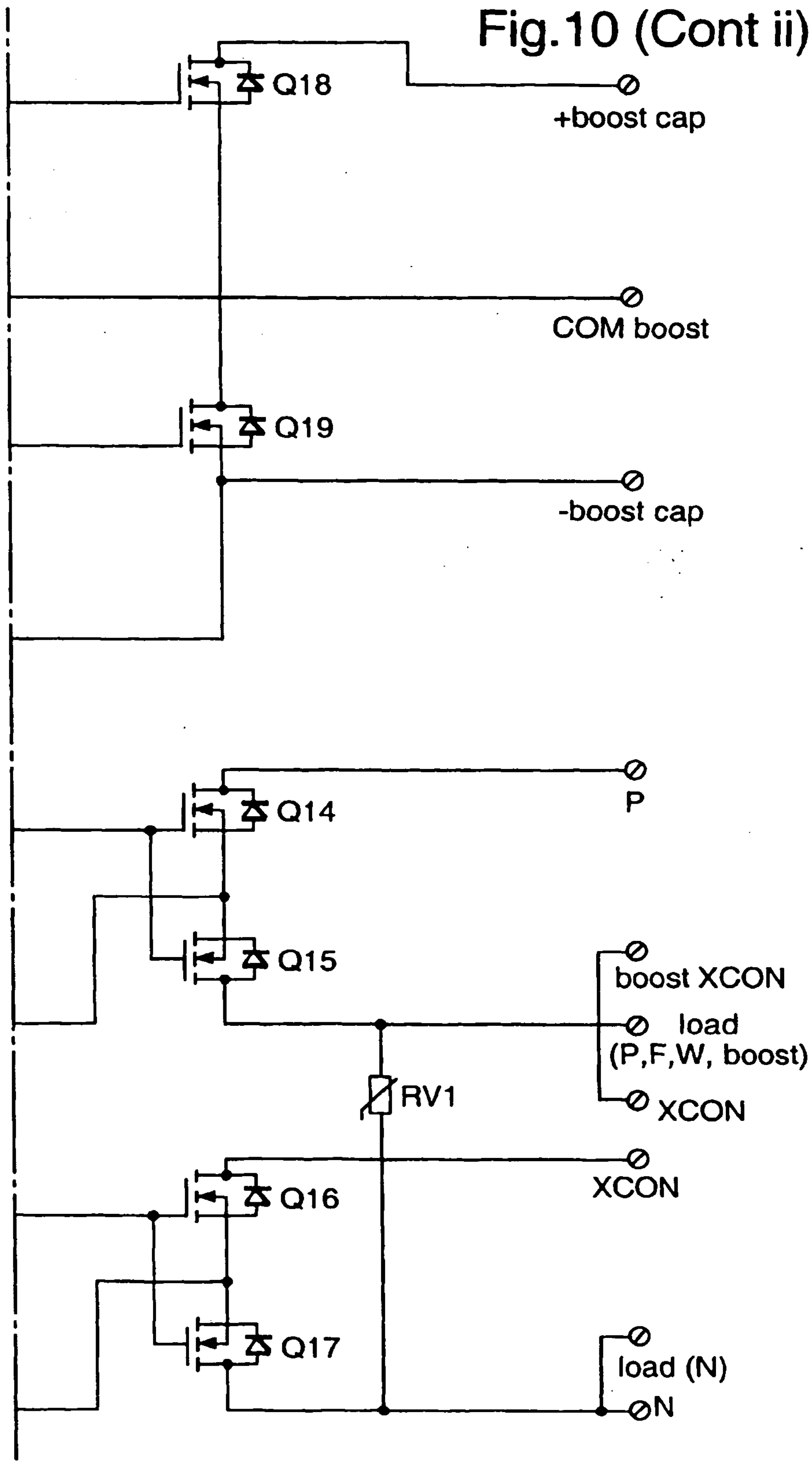

D24
R17
C3
D26
D27
R16
Q6
D19
D28
D30
R15
C4
D31
R14
Q7
D20
D23
D18
R13
D17
D16
R12
Q8
D21
D5
R11
C6
R10
Q9
D22

Fig.10 (Cont ii).



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(71) Applicant: Ein Hashofet Electrical Accessories
Kibbutz Ein Hashofet 19237 (IL)

(72) Inventors:
- Erez, Eran
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- Fishbein, Omri
  Ein Hashofet 19237 (IL)

(74) Representative: Franks, Robert Benjamin
Franks & Co., 8-10 President Buildings Saville Street East
Sheffield South Yorkshire S4 7UQ (GB)

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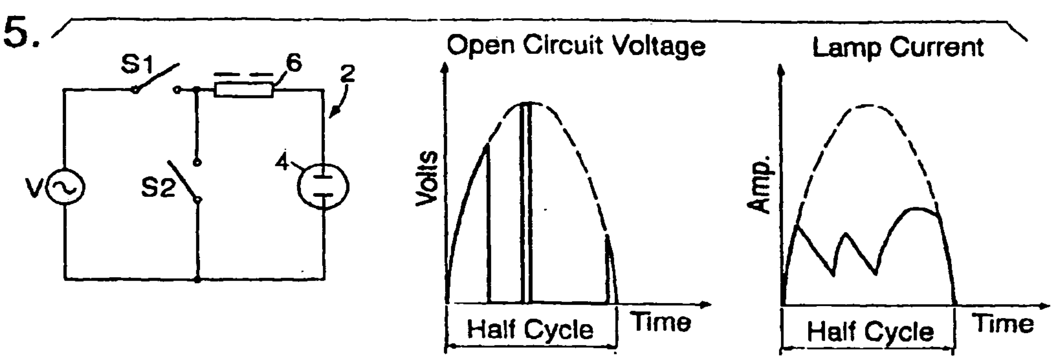
Fig.5.



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EUROPEAN SEARCH REPORT

Application Number
EP 00 30 2926

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 4 350 935 A (SPIRA JOEL S ET AL) 21 September 1982 (1982-09-21) * column 7, line 51 - column 18, line 18; figures 1-8 *	1-10	H05B41/392 H05B41/18
X	GB 2 269 948 A (AXIOMATIC DESIGN LTD) 23 February 1994 (1994-02-23) * page 3, line 57 - page 9, line 2; figures 1-5 *	1,8	
A,P	FR 2 771 589 A (SGS THOMSON MICROELECTRONICS) 28 May 1999 (1999-05-28) * page 4, line 29 - page 10, line 6; figures 3,4 *	9,10	
A	US 4 904 906 A (ATHERTON LARRY S ET AL) 27 February 1990 (1990-02-27)		
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A	US 4 899 088 A (BLACK JR ROBERT A ET AL) 6 February 1990 (1990-02-06)		TECHNICAL FIELDS SEARCHED (Int.Cl.7) H05B
A	EP 0 905 871 A (HELVAR OY) 31 March 1999 (1999-03-31)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 December 2001	Albertsson, E

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